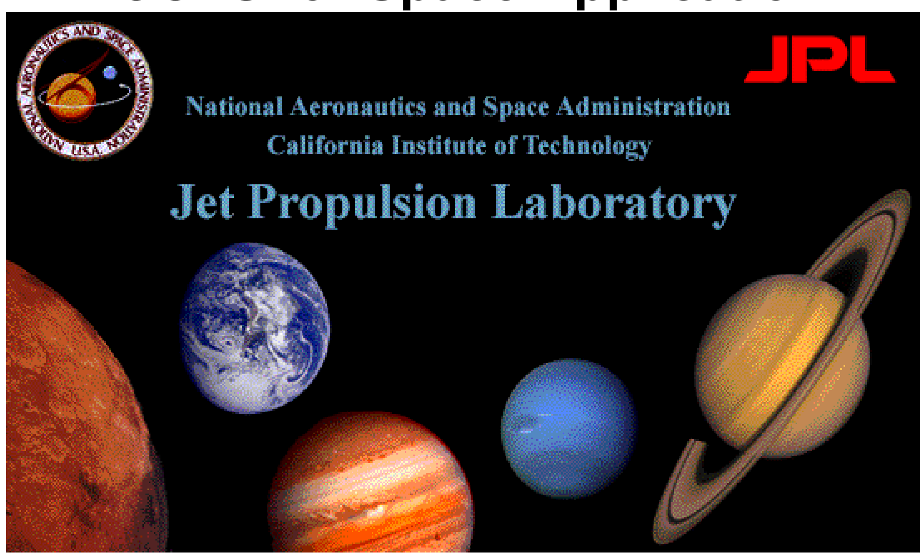
Electronic Components for the Commercialization of Military and Space Systems

1998 International Workshop

Commercial Off-The-Shelf (COTS)

Methodology and Experiences for Selecting COTS for Space Application



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Agenda

- Introduction
- Methodology for Selecting COTS
- Experiences of COTS Study & Usage
- Summary

Objectives (*guided rules*) for Our Methodology for Selection of COTS in SPACE

1. Detection, recognition, and elimination of potentially critical part problems that could lead to catastrophic mission failure.

2. Perform risk assessment and risk mitigation for those parts that may seriously limit or compromise mission objectives.

3. Establish parts criteria that systematically generates data and requires critical decision making even when data/information gaps occur.

Prior JPL Methodology for Selection-of-Parts was Founded on These Steps:

1 Vendor On-Site Team Surveys
2 Part Construction Analysis
3 In-House Evaluations
4 Extensive Controls /Gates
5 Extensive Reporting and Management Reviews
6 Destructive Physical Analysis
7 Failure Analysis When Needed
8 Extensive Data Reviews
9 Modeling for Failure Modes
10 Use of Rad Hard Foundaries

JPL COTS Methodology is Governed by Applying Continuous Incremental Decision Making:

- Define Tailored Parts Program with Cost
- Define Appropriate Parts Criteria List
- Define What Data/Information is Needed for Each Criteria
- Evaluate Available Data/Information For All Criteria
- Perform Risk Assessment/Mitigation As Necessary
- Assign an Appropriate Risk Level for Each Criteria That Satisfies Mission Requirements

Parts Criteria Derived for COTS Methodology

List of criteria used for COTS	Current Status	Evaluation
1. Vendor	Information Complete	Accept
2. Part	Information Complete	Accept
3. Wafer Fab Technology (Process)	Partial Information Received	Accept
4. Design	No Information Available	Unknown
5. Reliability Assurance	Dynamic Life Failures	Warning
6. Quality Assurance	No Information Available	Unknown
7. Testing	No Information Available	Unknown
8. Screening	No Information Available	Unknown
9. Performance	Partial Information Received	Accept
10. Package	Moisture Sensitive	Warning
11. Radiation	Partial Information Received	Unknown
12. Known Good Die	N/A	N/A
13. JPL Chip Overview	Information Complete	Accept
14. JPL DPA (Package)	Information Complete	Accept
15. JPL DPA (Die Cross Section)	Information Complete	Accept
7a. JPL Testing/Burn-In	Dynamic Burn-In Failure	Warning

Data Acquired for COTS Reliability Criteria

(Data example is specific for part type and/ or technology)

Reliability	Received	Unknown	Low	High	Waived	Accept
168 hr Infant Mortality	X					Accept (0/2000)
1000 hr Dynamic Lifetest	X			Burn-In Recommened (2 rejs.)		
Program Erase Cycle	X		Low risk for mission (1 failure out of 50K cyc.)		Waived for mission	
1000 hr Uncycled High Temperature Storage	X					Accept (0/180)
Endurance		Unknown				
Data Retention		Unknown				

Critical review of vendors own data can uncover potential reliability concerns.

COTS Part Construction Analysis Data

Manufacturer	Part No.	Date Code	LOG No.	Package	Completed	Results	Work by
Linear Technology	LT1076CT	9524	6746	5 LD TO-220	10/3/96	Accepted	JPL
Linear Technology	LT11172IN8	9530	6747	8 LD DIP	10/3/96	Accepted	JPL
Linear Technology	LT1176CN8	9512	6748	8 LD DIP	10/3/96	Accepted	JPL
Linear Technology	LT1111CN8	9330/9543	6749	8 LD DIP	10/8/96	Accepted	JPL
Linear Technology	LT1352CN8	9613	6750	8 LD DIP	10/8/96	Accepted	JPL
Linear Technology	LT1211CN8	9625	6751	8 LD DIP	10/8/96	Accepted	JPL
Linear Technology	LT1243IN8	9338C	6752	8 LD DIP	10/8/96	Accepted	JPL
Linear Technology	LT1373CN8	9532	6753	8 LD DIP	10/8/96	Accepted	JPL
Linear Technology	LTC1257IN8	9440/9521	6754	8 LD DIP	10/8/96	Accepted	JPL
Linear Technology	LTC1047CN8	9537	6755	8 LD DIP	10/8/96	Accepted	JPL
INTEL CORP.	DA28F016SV	N/A	6745	56 LD SSOP	10/17/96	Accepted	JPL
INTEL CORP.	DA28F016SV	N/A	9614082D1	56 LD SSOP	10/17/96	Accepted	DPA
CATALYST	CAT28F020P	09550B	9614082D2	32 LD DIP	10/15/96	Accepted	DPA
AMD	AM28F020	9608/9618	9614082D3	32 LD DIP	10/15/96	Accepted	DPA
Linear Technology	LTC1419CS	9624	6756	28 LD P. SOIC	10/8/96	Accepted	JPL
Vendor A	2N2605	None	6848	T0-46	2/17/97	High Risk	JPL
Analog Devices (ADI)	AD768AR	9633	6856	28 LD P. S. M.	3/14/97	Accepted	JPL
GEC Plessy	NJ88C33	9617	6878	14 LD DIP	5/1/97	Accepted	JPL
National Sem.	LMX2332L	None	6873	20 LD P. S. M.	4/30/97	Accepted	JPL
National Semi.	LMX2315	None	6872	20 LD P. S. M.	4/30/97	Accepted	JPL
Vendor B	ADS-937	9623/9648	6773	32 LD SB	5/1/97	Failed DPA	JPL
Signal Process.Tech.	SPT7725AIQ	9552	6855	44 LD Cq S. M.	3/14/97	Accepted	JPL
Maxim	MAX101CFR	9436	6854	84 LD C. FP	3/11/97	Accepted	JPL

The majority of vendors evaluated passed JPL criteria

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Plastic Packages Outgassing Data

Material	MCR			7612382FBA, E24, DA28F016SV, K8055, U6240332			AM28F020-150PC, 9618FBB			CSI, CAT28F020F, 1-15 09550B		
Part	Motorola SCR			Intel 16 M Flash Memory			AMD 2M Flash Memory			Catalyst 2M Flash Memory		
Sample No.	5	6		7	8	a	9	10		11	24	
WT. Loss %	0.45	0.46	0.45	0.23	0.22	0.22	0.41	0.45	0.43	0.40	0.41	0.40
Water Vapor Recovered, WVR, %	0.28	0.25	0.26	0.14	0.11	0.12	0.19	0.17	0.18	0.21	0.18	0.19
TML (WT, LOSS-WVR) %	0.17	0.21	0.19	0.09	0.11	0.10	0.22	0.28	0.25	0.19	0.23	0.21
CVCM %	0.04	0.08	0.06	0.02	0.01	0.01	0.03	0.05	0.04	0.04	0.04	0.04
DEPOSIT on CP	Opaque			Negligible			Opaque			Opaque		
FTIR Results	Amine cured epoxy			Anhydride cured epoxy			Amine cured epoxy			Amine cured epoxy		

Conclusion: All materials passed. These tests are suited for lot-to-lot comparisons, tracking manufacturing continuity/changes, and measuring absorbed moisture at a known environment.

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A/D COTS Radiation Data

P/N	Resolution	Process	VDD	Power	Speed	Total Dose	SEL
LTC1419	14-Bit	CMOS	+/- 5V	150 mW	800 Ksps	TBD	None, LET> 100 MeV/mg/cm2
SPT7725	8-Bit	Bipolar	- 5.2V	2.2 W	300 Msps	>100 Krad (Si)	None, LET> 100 MeV/mg/cm2
HI1276	8-Bit	Bipolar	- 5.2V	2.8 W	500 Msps	TBD	None, LET> 100 Mev/mg/cm2
AD7714-3	24-Bit	CMOS	+ 3V	2.6 mW	See data sheet	TBD	LET = 55 Mev/mg/cm2
ADS7809	16-Bit	CMOS	+ 5V	100 mW	100 Ksps	10 Krad (Si)	LET = 19.9 MeV/mg/cm2

Each part must be evaluated on its own merit & per mission requirements before acceptance

Validation of C-SAM Results Obtained on 3 PEMs

Precondition: 85°C/85RH for 500, 600, & 900 hrs

Found by C-SAM	Cross Section Found
Voids Near Pins (3)	Mylar Tape and Small Bubbles (3/3)
Voids at Lead Egress (1)	Thin plastic/cu oxide (1/1)
Voids at die edge (1)	Nothing (1)
Die Attach 90% Voided (1)	No Die to Frame Adhesion (1/1)

Correlation on 3 parts: 5/6

Note: Voids (delamination) are indicated as a red area with C-SAM analysis.

Case Study - COTS Experience

Mars Pathfinder used a COTS hybrid converter because of cost & schedule constraints. They ordered to a military temperature range from a non-QML supplier. Early samples showed problems which were aggressively worked with the vendor. New builds were better and performed well.

Some subsequent JPL projects ordered converters from the same vendor without the same rigorous follow-up, we found:

Corrective actions from Mars Pathfinder did not persist

11/13 DPA samples from different lots were rejected

JPL source inspection led to many rejects (19/20 lots)

8 operational failures in hardware

Extensive effort required to solve the problems proved very expensive

Lesson : Successful COTS infusion requires great diligence.

Concerns with Using COTS / PEMs in Space	Findings/Resolution
• Long Term Storage	Space is benign for moisture
• PEM Assembly Defects	C-SAM Screening is Effective
• Moisture Absorption	Use Proper Handling for Moisture Sensitive Parts
• Reliability Unknown	Use COTS Methodology
• Rad Tolerance Unknown	COTS Must Be Tested
• Outgassing in Space	Ø Rejects to NASA Spec
• Glass Transition Temp.	Space Applications<<Tg

Conclusions Thus Far:

- Using COTS without understanding their performance can lead to mission delay, increased cost, or worst ➡ Mission Failure
- JPL is using the described methodology to minimize the reliability/radiation risk of using COTS
- Our studies/experiences of COTS concerns thus far, have not exclusively disqualified them for Space, but rather confirmed they must be selectively and carefully evaluated case by case
- Thorough characterization can lead to successful applications
- A COTS methodology/evaluation should be part of an integral system risk reduction program